

REMARKS

Summary of Office Action

Claims 1-14, 17-21, and 35-52 are pending. Claims 15, 16, 22-34, and 54-64 have been withdrawn as being drawn to a non-elected species.

Claims 1-3, 7, 14, 17-21, 35, 36, 43, 44 and 51-52 have been rejected variously under 35 U.S.C. § 102(e) and § 103(a): claims 35, 36, 43, 44, and 48 as anticipated by Mann U.S. patent No. 5,828,793 ("Mann"); claim 44 and 51 as anticipated by Tatko U.S. patent No. 6,501,504 ("Tatko"); claims 1 and 21 as obvious from Mann in view of Burger U.S. patent No. 6,124,974 ("Burger"); and claims 1-3, 7, 14, 17-20, 45-47 and 52-53 as obvious from Mann in view of Laroche U.S. patent No. 5,373,322 ("Laroche").

The Examiner indicates that claims 4-6, 8-13, 37-42, 49 and 50 contain allowable subject matter, and that these claims would be allowed if rewritten in suitable form.

Applicants' Reply

Applicants appreciate the Examiner's indication of allowable subject matter in claims 4-6, 8-13, 37-42, 49 and 50.

Applicants have amended claims 1, 35 and 44 for clarity. Applicants respectfully traverse the prior art rejections of claims 1-3, 7, 14, 17-21, 35, 36, 43, 44 and 51-52.

Applicants' Invention And Claim Amendments

Applicants' invention concerns systems and methods for capturing high dynamic range images using low dynamic range sensors. Applicants' systems and methods are able to capture a high dynamic range image with a low dynamic range image sensor by imposing a

spatial variation on the scene exposure in a single image frame captured by the image sensor.

The exposure of the scene is varied spatially (e.g., claim 44) by using arrangements, which either modulate the light from the scene (e.g., using an intervening spatially-varying mask, claim 1) or by using an image sensor that has spatially varying characteristics (e.g., using sensor elements with spatially varying photosensitivity, claim 35). In either arrangement, the scene is imaged or exposed in a spatially non-uniform manner by the image sensor (claim 1, 35 and 44).

Applicants note that the term "spatially varying exposure" of the scene in a single image frame refers to imposed imaging conditions, and not to the inherent dynamic range of the scene (i.e., spatial variations or distributions of light intensity radiating from the scene). Thus, even for a "blank" scene having a uniform or constant spatial radiance (i.e., $I(x, y) = \text{constant}$, for all x and y), applicants' image sensors capture a non-constant image frame (i.e., which is not uniform in x and y). Applicants' inventive concept of imposing "a spatially varying exposure" or imaging of a scene utilizing a spatially non uniform "sensing" capability has been fully and repeatedly explained in the specification.

Applicants have amended claims 1, 35 and 44 to emphasize that it is the image sensor which has a spatially non-uniform sensing capability. For example, claim 35 now recites "the light-sensing elements are configured to have respective photosensitivities [] that vary spatially across the array so that [] the array of light sensing elements impose a spatial variation the scene exposure". Similarly, claim 44 now recites "the array of light sensing that is configured so that the sensing capability of the image sensor varies spatially across the array during the sensing of the image frame, whereby the sensed image frame is an image formed with a spatially varying exposure of the scene". Further, claim 1 now recites "scene light transmitted on to the light sensing elements is attenuated by brightness level amounts that vary spatially".

across the array of light-sensing elements, and whereby the scene is exposed to the light sensing elements in a spatially varying manner"

Prior Art Rejections

Independent Claims 35 and 44

Claims 35 and 44 have been rejected as anticipated by Mann (Office Action § 4).

Applicants respectfully submit Mann does not show, teach or suggest imposing a spatial variation on the scene image frame recording conditions as required by claim 35. Like the prior art cited by the applicants (see e.g., specification page 2 lines 15-20), Mann requires exposing multiple [uniform exposure] temporal images of a scene and then reconstructing an improved dynamic range image from the multiple image frames acquired by a sensor.

Mann, in particular, "combines a plurality of differently exposed source images of the same object or scene." (Col. 3 lines 34-36).). Each of Mann's "differently exposed" images is in fact uniformly imaged or exposed. Each of Mann's image frames, which are captured on photographic film, is "differently exposed" by use of different but uniform camera exposure settings (e.g., lens aperture, exposure time or shutter speed). (See e.g., Col. 5 lines 25-62). Further, the image sensor or photographic film used by Mann has uniform properties. There is nothing in Mann that says or suggests that the image sensor or photographic film has or should have spatially non-uniform photosensitivity or sensing capabilities as is required by applicant's claim 35 and 44.

In this context, the Examiner mistakenly states that Mann's figures 1- 4 are "spatially varying photosensitivities" (Office action §3, page 3, first complete paragraph)). These figures in fact represent results -- scene images, (i.e. "exposed photographs" or "scene intensity

distribution"), at uniform exposure settings using imaging film of uniform photosensitivity. (See e.g., col. 5 lines 25- 47). These figures relate, as one would expect, to an image which is spatially varying simply because of the spatial intensity distribution or variation inherent in the scene. These figures do not, however, teach, show, or suggest "imaging" or "exposing" the scene in a spatially varying manner as required by applicants' invention.

In particular, Mann does not show, teach or suggest either the claim 35 limitation that the light-sensing elements (e.g., photographic film or CCD) have photosensitivities that vary spatially across the array, or the claim 44 limitation that the sensing capability of the image sensor vary spatially across the array of light-sensing elements.

Claim 44 also has been rejected as anticipated by Tatko. (Office Action § 5). However, Tatko like Mann involves exposing multiple [uniform exposure] temporal images of a scene for range improvement (e.g., by alternately exposing "one frame of the video [] captured at high gain setting" and "a subsequent frame [] captured at a low gain setting"). (See e.g., col. 3 lines 29-33). Each of Tatko's video frames is an uniform imaging or exposure of the scene using the same exposure setting (e.g., gain, aperture) across the scene. Like Mann, there is nothing in Tatko that shows, teaches or suggests "imaging" or "exposing" the scene in a spatially varying in the manner of applicants' invention.

In particular, Tatko does not disclose the claim 44 limitation that the sensing capability of the image sensor varies spatially across the array.

For at least the foregoing reasons, claims 35 and 44 are patentable over Mann and Tatko. Further, claims 36-43 and 45-53 that respectively depend from claims 35 and 44, also are patentable.

Independent Claim 1

Claim 1 has been rejected as being obvious from Mann in view of either Laroche or Burger (Office Action §§ 8 and 9).

Applicants respectfully submit that there is no motivation to combine the references, and further, neither Mann, Laroche nor Burger, whether taken individually or in combination, disclose all the elements of claim 1.

Mann, as discussed above, discloses taking multiple temporal images of a scene each taken at an uniform exposure setting, to improve the dynamic range of an image sensor. However, as discussed above, Mann does not show, teach or suggest "spatially varying" a single exposure of scene (in a single image frame) to improve the dynamic range of an image sensor.

Laroche, as the Examiner correctly notes (Office Action, § 8 page 20), is directed to reducing color edge artifacts and improving edge sharpness in color photography using a color mask. In particular, Laroche discloses algorithms for processing color images acquired by a conventional image sensor using a conventional color filter/mask arrangement. (See e.g., col. 2, lines 7-29). However, applicants submit that the Examiner mistakenly states that Laroche provides motivation for combination with Mann. Laroche does not show, teach or suggest deploying a color filter/mask mask to "improve" in any way the dynamic range of the image sensor or of the color image. Thus, Laroche fails to provide any motivation to include a mask in Mann's scheme for dynamic range improvement.

Similarly, Burger does not provide any motivation to include a mask in Mann's scheme for dynamic range improvement of images of a scene. Burger uses a configuration of

optical elements (e.g., FIG. 19 stacked array magnifier (SAM) 350 made of lenslets) to magnify and/or demagnify images (i.e., "to form a scaleable display of flat panel displays.") (See e.g., Abstract). There is no increase in the dynamic range of the image by any of Burger's stacked array magnifiers, which can only change the image size or format.

Thus, neither Burger nor Laroche provide any motivation to include a mask in Mann's dynamic range improvement schemes.

In any case, neither Mann, Laroche or Burger, whether taken individually or in combination disclose an intensity mask, that according to claim 1, attenuates "scene light by brightness level amounts that vary spatially across the array of light-sensing elements, and whereby the scene is exposed to the light sensing elements in a spatially varying manner."

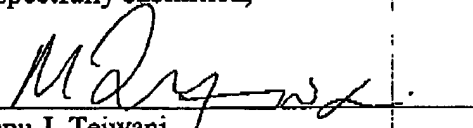
Thus claim 1 is patentable over the cited references. Further, claims 2-34 that depend from claim 1 also are patentable.

Conclusion

For the reasons set forth above, applicants request that prior art rejections of claim 1-3, 7, 14, 17-21, 35, 36, 43, 44 and 51-53 be withdrawn. Applicants respectfully submit that this application is now in condition for allowance. Reconsideration and prompt allowance of which are requested.

If there are any remaining issues to be resolved, applicants request that the Examiner kindly contact the undersigned attorney for a telephone interview in order to advance the prosecution of this case.

Respectfully submitted,



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